
Space Weather Technical Forecast

Issued on Sunday, 04 December 2022 at 13:06 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Active high energy electron fluence. Daily chance of M-flares. Chance of G1/Minor Storms Day 4 (7 Dec).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate with one impulsive M1.3 flare at 03/1741 UTC, likely emanating from AR3157, emerging from the northeast limb. A few minor C-class flares were also recorded. There are currently five numbered and three unnumbered regions on the visible disc. Large and mature region AR3153 Fho/Beta in the southeast remains stable. The main developmental region observed was AR3155 Dsi/Beta in the northwest. No Earth-directed CMEs were observed in the last 24 hours. However, CME imagery of a small filament eruption in the northeast is yet to be analysed.

Solar Wind / Geomagnetic Activity: Declining influence of CH51/+ was observed, with Elevated solar wind speeds at L1 from ACE/DSCOVR easing from around 600km/s to around 500km/s. The density of the wind increased around 04/0000 UTC from average to just above average, where it has largely remained. Total IMF, Bt, was generally weak between 3-7 nT. The north-south component Bz was variable, fluctuating between -6 nT and +5 nT. Phi angle was largely negative at first (towards the Sun) but became predominantly positive (away from the Sun) after 03/2025 UTC. Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 has remained at Background levels. High energy electron flux (greater than 2MeV) at GOES-16 has been High throughout, peaking at 17480 pfu at 03/1740 UTC. The associated 24-hour Fluence was above the Active (1e8 integrated pfu) threshold throughout with a steadily increasing trend which has largely plateaued. Observed fluence at 04/0000 UTC was 5.71e8 integrated pfu.

Four-Day Space Weather Forecast Summary

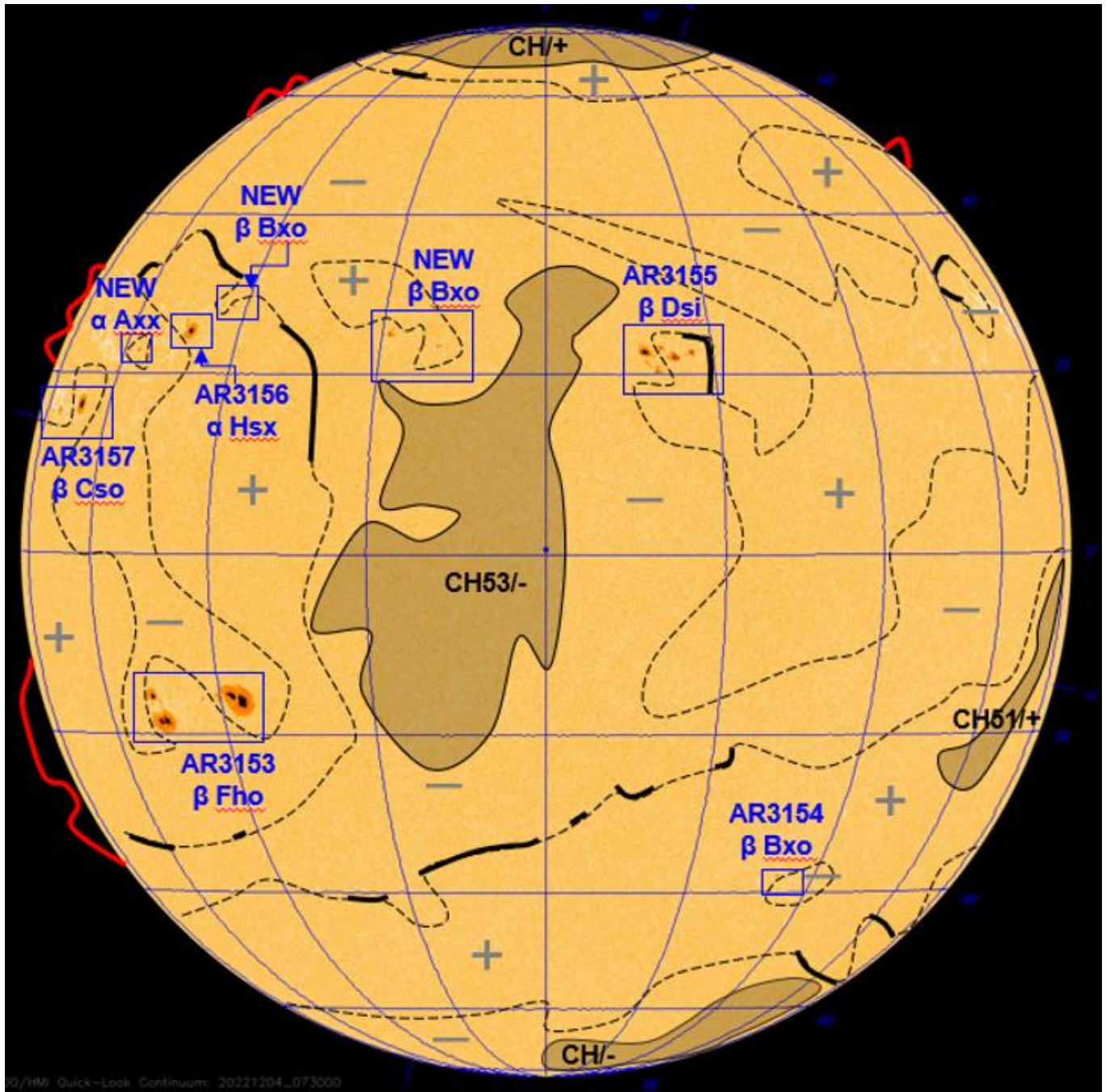
Solar Activity: Low activity is expected to prevail, with further C-class flares, and the daily chance of isolated M-class flares increasing activity to Moderate.

Solar Wind / Geomagnetic Activity: Low confidence in the arrival on Day 1 (4 Dec) of a slow CME from a filament eruption on the 29 Nov. Waning effects of a HSS from CH51/+ with wind speeds expected to decline towards Background. The next HSS is expected to arrive on Day 4 (7 Dec) from CH53/-, peak winds 500-600 km/s likely. Mainly Quiet to Unsettled geomagnetic activity expected through Days 1-3 (4-6 Dec), although potential CME arrival on Day 1 brings the chance of a spell of Active intervals and a slight chance of G1/Minor Storms. Activity increasing to Unsettled to Active with a chance of G1/Minor storm intervals Day 4 (7 Dec).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) at GEO, as observed by GOES-16, is expected to remain at Background throughout. High energy electron flux (greater than 2 MeV), as observed by GOES-16, is expected to remain predominantly High, until at least Day 4 (7 Dec), with Fluence levels persisting above the Active (1e8 integrated pfu) fluence threshold. There is a chance of a brief drop out in flux Day 1 from a CME arrival, however this is low confidence.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

Figure 1. Solar Analysis Valid 04/0730 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The CME produced by a filament eruption on 29 Nov was assessed as slow, with the possibility of an Earth-directed component arriving on Day 1 (4 Dec). Although this is low confidence, it is supported by MOSWOC Enlil output. Other recent CMEs are not anticipated to impact Earth during the forecast period.

The effects of a HSS from CH51 are expected to wane through Day 1 (4 Dec) as the feature rotates beyond the western limb and the connection is severed. Some enhancement is possible on Day 1 if the weak CME arrives, otherwise, winds are projected to fall to Slow-Ambient levels. The next enhancement is expected to be the arrival of a high speed stream from CH53/- on Day 4 (7 Dec). This coronal hole is markedly larger than on its previous rotation, as such, recurrence modelling and SWPM are thought to give poor guidance later in the period. MOSWOC Enlil suggests peak winds of 500-600 km/s arriving on Day 4. As we approach the December Solstice, geomagnetic response to fast winds arrivals are less likely to be significant, however there is still a chance of isolated G1/Minor Storm intervals.

Mainly Quiet to Unsettled geomagnetic activity expected through Days 1-3 (4-6 Dec), although the potential CME arrival on Day 1 results in the chance of Active intervals and a slight, but diminishing, chance of isolated G1/Minor Storms. Activity is expected to increase to Unsettled to Active on Day 4 (7 Dec) with a chance of G1/Minor storm intervals.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	1	10	40
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/1246 and 30/0730	Partial	Filament	SE	300km/s and 320km/s	04/0600 +/- 9hrs	Modelled as 2 CMEs. Limited shock expected. Low confidence



Figure 2: MOSWOC Enlil showing potential arrive of weak CME, and enhancement on 7 December

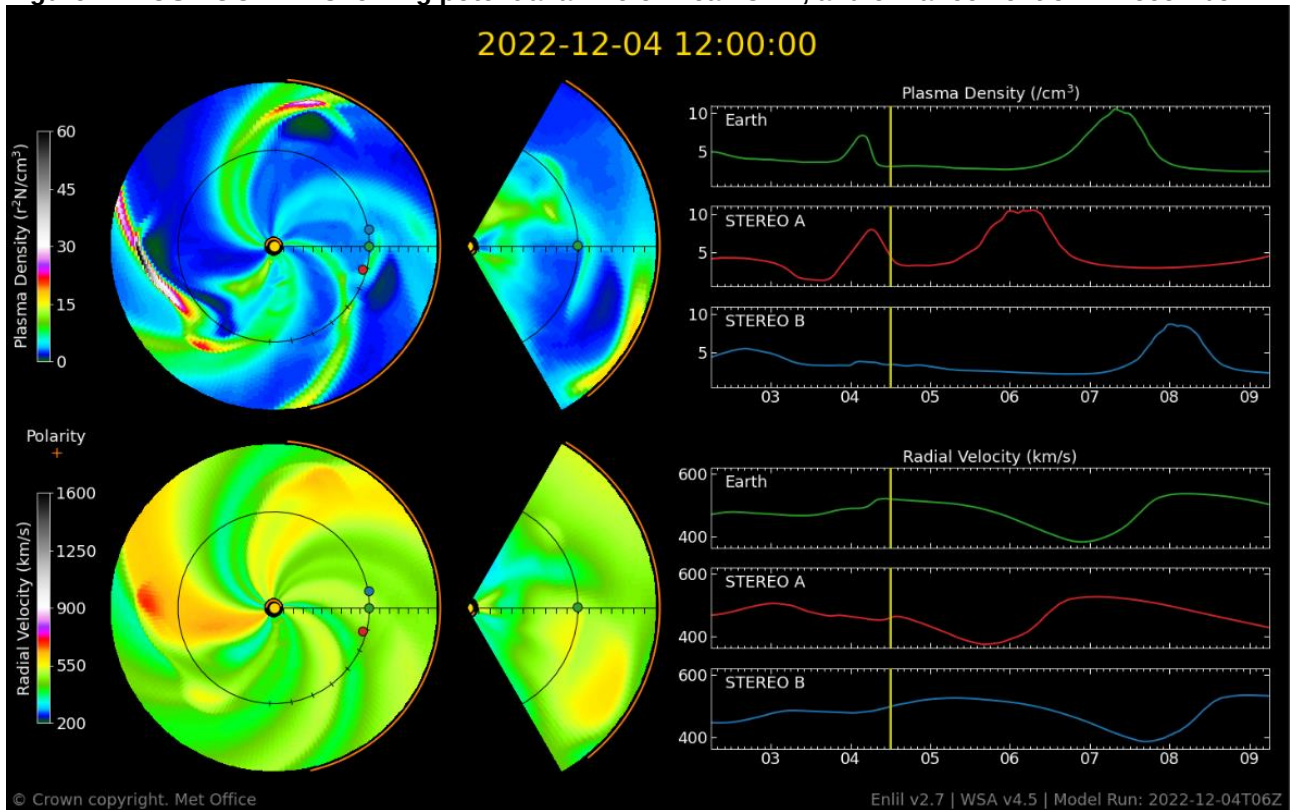
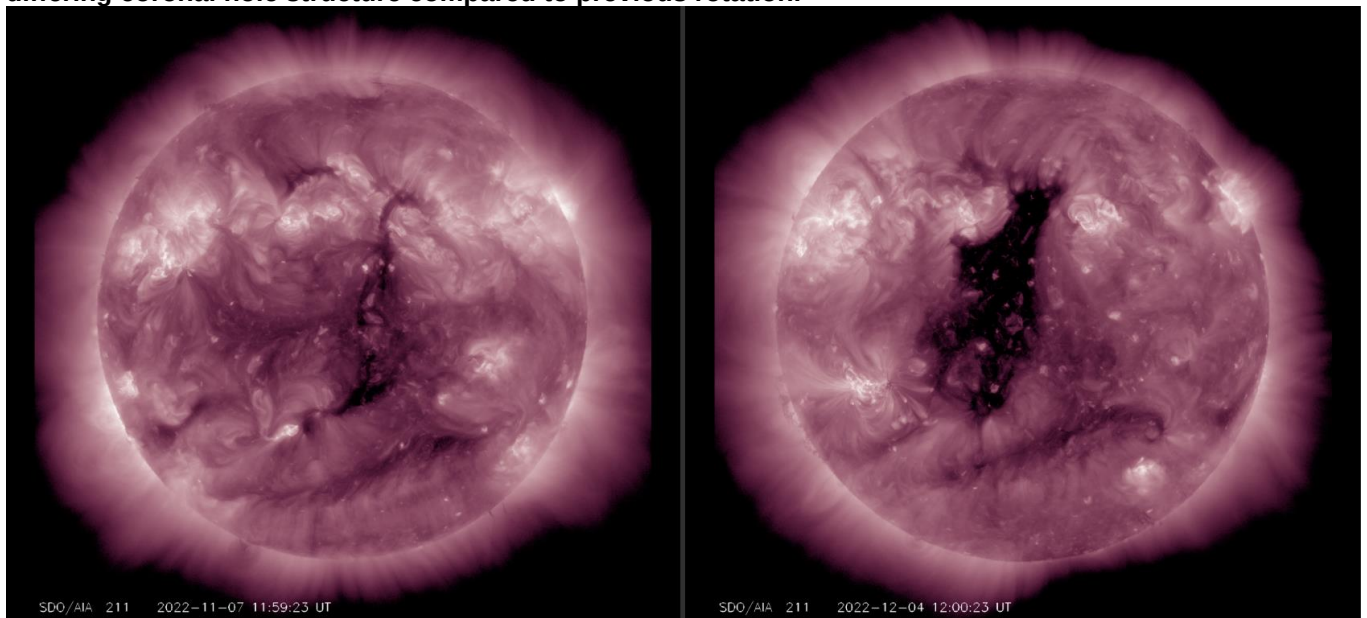


Figure 3: SDO/AIA-211 Imagery showing previous (left) and current (right) rotation. Images show differing coronal hole structure compared to previous rotation.



Radio Blackouts - X-Ray Flares:

Solar activity is expected to remain Low, but with the ongoing chance of increasing to Moderate with further isolated M-class flares.

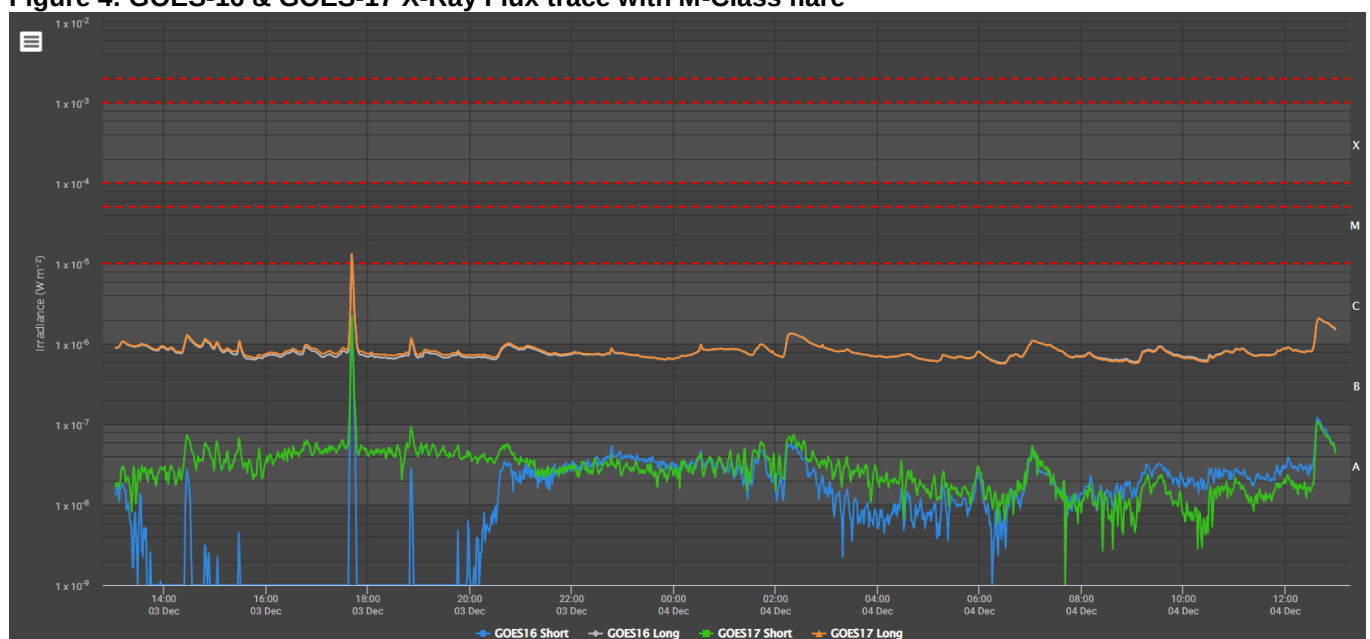
The largest sunspot remains AR3153 Fho/Beta in the southeast. Despite the significant magnetic flux associated with this region, it remains relatively stable and notable flaring is unlikely from this region.

The main developmental region is AR3155 Dsi/Beta in the northwest, with continued proliferation of small intermediate spots and some increase in penumbral extent. AR3157 Cso/Beta continues to emerge across the limb in the northeast, this was likely the source of the impulsive M1.3 flare on the limb at 03/1741 UTC. It is currently assessed as a relatively simple bipolar region (Cso/Beta) but will need reanalysing as it rotates into a clearer view.

AR3156 Hsx/Alpha remains a relatively large but simple, stable, and mature region. AR3154 Bxo/Beta in the southwest continues to fade. The three unnumbered regions are currently small and simple.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 4: GOES-16 & GOES-17 X-Ray Flux trace with M-Class flare



Solar Radiation Storms - (High Energy Protons):

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

The high energy proton flux (greater than 10MeV) at GEO, as observed by GOES16, is currently at Background levels and is expected to remain at this level throughout the period. However, any significant flares from either AR3153 or AR3155 could give a very slight chance of observed protons at Earth increasing towards the S1/Minor Radiation Storm level.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	2	2	2	2
Very Active	$\geq \text{S3}^*$	No	1	1	1	1

* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)

High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2 MeV), as observed by GOES16, is currently at High levels. In the absence of any disturbance due to the possible arrival of a CME on Day 1 (4 Dec), flux would be expected to persist at these levels until the arrival of a HSS from CH53 on Day 4 (7 Dec), at which point the observed flux is likely to fall to Background levels. The potential arrival of a weak CME on Day 1 poses uncertainty in the forecast, as would likely result in flux levels dropping out for a period, before recovering, probably to High levels, by Day 2 (5 Dec).

Associated fluence is expected to remain Active (above $1\text{e}8$ integrated pfu) for much of the period as indicated by REFM. However, as with flux values, the potential impacts from a CME arrival decrease confidence levels from Day 2 onward. Given the current observed flux, if the CME arrival doesn't occur on Day 1, then it is possible that Very Active ($1\text{e}9$ integrated pfu) levels may be briefly reached.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	Yes	100	90	80	80
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	5	10	5	1

Figure 5: REFM showing steady increase in fluence levels

